Sixty Years of Change on a Central Arizona Grassland-Juniper Woodland Ecotone

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ABSTRACT

Vegetation changes over 60 years in central Arizona grassland-juniper woodland ecotone sites are documented with 20 matched photograph pairs. Land use information between photograph dates, climate, and soil helps to explain and elaborate on differences shown. Grazing use markedly affected understory species. Junipers numbers and sizes increased markedly on hillsides and rocky ridges, but did poorly on bottom land sites. Utah juniper rapidly reestablished on areas cleared of juniper trees in the 1950's and 1960's. The open growth habit of many Utah junipers indicates the trees are growing under marginal conditions. Brush stands of shrub live oak, clifrose, mountain mahogany, and Apache-plume did not spread, but shrub crown cover increased greatly.

KEYWORDS: Pinyon-juniper, vegetation change, ecotone, soil, Utah juniper, invasion, grazing history, grassland.

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INTRODUCTION

There is widespread interest in restoring range and forest lands to their earlier, pristine conditions; however, it is often difficult to determine what was present before the occurrence of major disruptions such as overgrazing and reduced fire frequency. The establishment of juniper (*Juniperus* spp.) on former grasslands has been reported a number of times, but largely without photographic documentation.[2] [3] [4] [5] [6] This paper presents 20 matched pairs of photographs taken 60 years apart in grassland-juniper ecotone areas in central Arizona. These pictures, along with information about area vegetation, soils, and history of grazing use, may help land managers, researchers, and others to understand the pinyon-juniper ecosystem better and to improve its management.

Photographs of northern Arizona pinyon-juniper areas taken between 1916 and 1918 were recently found in arable land survey reports made in response to the Forest Homestead Act of June 11, 1906. One of these reports, "Intensive Land Classification, Baca and Prescott Divisions, Prescott National Forest, Arizona," written by Rex King, Forest Examiner, had 21 photographs taken in grassland-juniper woodland ecotone areas between Prescott and Seligman on the current Yavapai Allotment of the Walnut Creek Ranger District, Prescott National Forest. King did not state when the pictures were taken, but the fieldwork was done July 15 to 30, 1916, and July 4 to 20, 1918. For convenience, we refer to the earlier photographs as being made in 1916.

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[2]Foster, J. H. The spread of timbered areas in central Texas. Journal of Forestry 15: 442-445. 1917.

[3]Johnsen, T. N., Jr. One-seed juniper invasion of northern Arizona grasslands. Ecological Monographs 32: 187-207. 1962.

[4]Miller, F. H. Reclamation of grassland by Utah juniper on the Tusayan National Forest, Arizona. Journal of Forestry 19: 647-651. 1921.

[5]Parker, K. W. Juniper comes to the grassland. American Cattle Producer 27: 12-14. 1945.

[6]Wolff, S. E. An evaluation of some weedy Texas junipers. U.S. Department of Agriculture, Soil Conservation Service, Western Gulf Region, 89 pp. 1948.

Annual precipitation in this area averages 10 to 16 inches with dry springs and falls. Precipitation occurs mainly during the summer and winter. Summer rains generally fall as high intensity, localized thunderstorms in July and August. Winter precipitation usually occurs from December to March as low intensity, general storms with snow common above 5,000-ft elevations.

The six summers before the 1977 photographs were taken were dry, especially in the late summer. The summer of 1977 was wet with plentiful rainfall from mid-July through August.

At the time of the early surveys, livestock freely roamed the area, there being few fences until about 1935. Livestock grazing of this area first began in the mid-1860's, on reputedly dense stands of grasses, to provide meat for the military camps established to deter Indian raids. The subsequent building of the railroad in 1883 provided a means of shipping livestock to the eastern markets and resulted in the cattle industry's rapid expansion. Near the end of the 1880's, large numbers of cattle roamed over the area. Because they were in unrestricted open range, the livestock went wherever there was feed and water. With little dependable water north of Walnut Creek, Ariz., cattle concentrated near the watering places and along the trails between waters. Areas near water became markedly overgrazed while unwatered rangeland was relatively ungrazed.

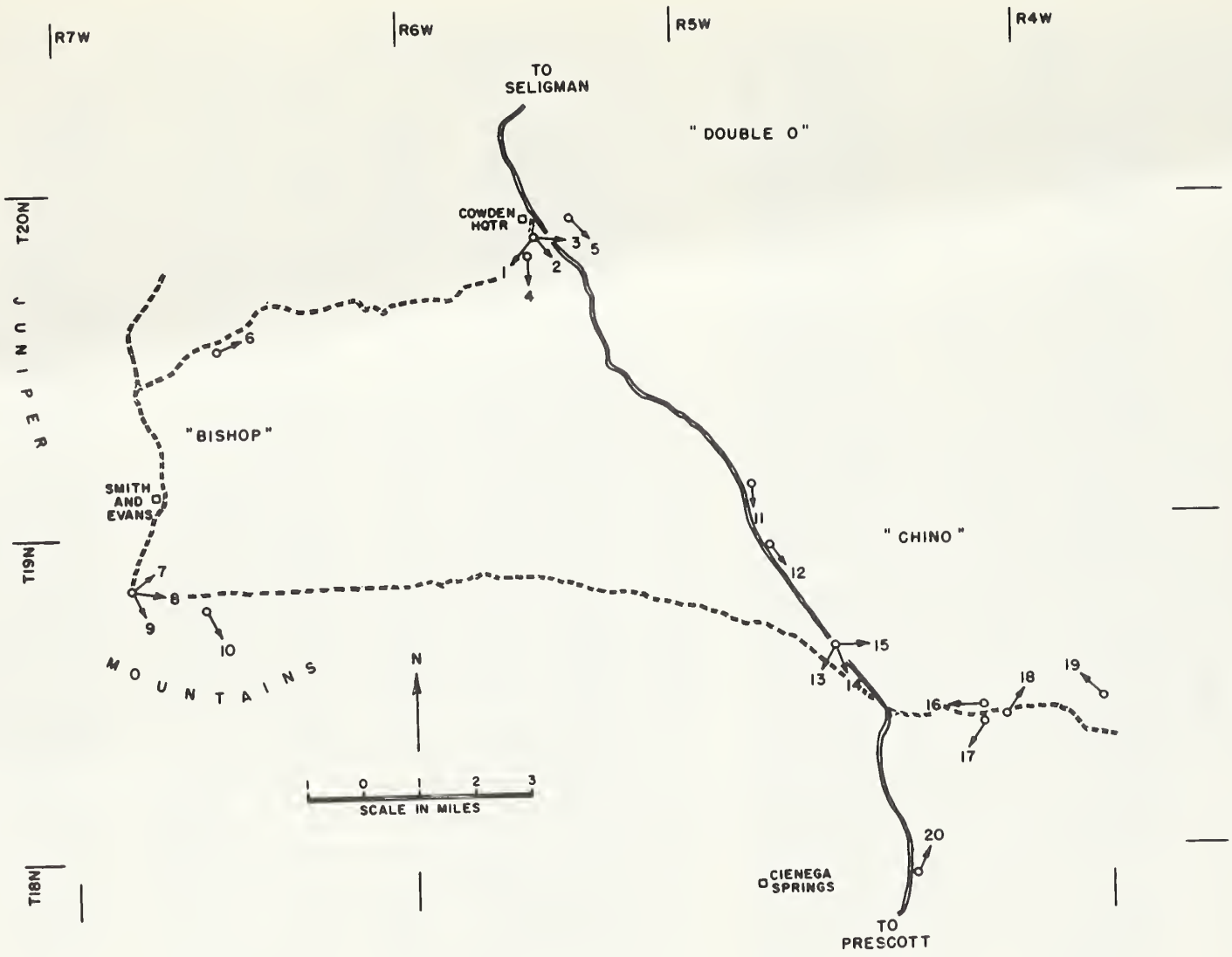
The livestock were rounded up annually and driven across the Yavapai Allotment to the railhead at Seligman, Ariz., the last drive being in 1945. Many of the freely roaming cattle were never collected in the roundups and continued to multiply and graze the range all year. Overgrazing, coupled with severe droughts, depleted the forage, resulting in heavy losses of livestock due to starvation and thirst in the 1890's. The practice of unrestricted open range grazing continued until after the establishment of the Prescott National Forest Reserve in 1898; however, the prior excessive grazing had depleted the grass cover, and soil erosion was severe.

Many sheep and goats also used the area from the beginning of the 20th century into the 1930's when, due to a declining market, their numbers fell. The cattle ranch on the Yavapai Allotment was not stocked during the dry years in the early 1930's, but was leased for cattle use from 1935 to 1938 and then again was unstocked. The ranch ownership changed in 1940, introducing a period of range management aimed at improving range conditions, dependable well water development, and juniper removal.

PROCEDURE

Originally, 21 pictures were taken at 15 different locations, but only 14 of the 15 locations were found (map 1). Five picture pairs were taken at three locations on the Double 0 Division and five picture pairs at three locations on the Bishop Division on the northern and northeastern sides of the Juniper Mountains. Another 10 picture pairs were taken at eight locations east of these mountains on the Chino Division in the area bordering the Big Chino Valley grasslands.

During October 1976, the general locations of original photograph sites were relocated. Observations of the vegetation and soil were made, and soils were classed by a soil scientist. Photographs were taken to document site conditions.



Map 1.--Location of photopoints and direction in which pictures were taken for matched photograph pairs, showing vegetation changes between 1916 and 1977 on the Prescott National Forest north of Prescott, Ariz. Numbers refer to figure numbers in the text.

Pictures matching the originals were taken July 25 to 27, 1977, about the same time of year the originals were taken. We marked each photopoint with a short steel fencepost driven into the ground and labeled with a metal tag, indicating photopoint number and years when pictures were taken.

RESULTS AND DISCUSSION

Photographic comparisons of nine locations showed little or no ground vegetation change in the photographs' foreground. Four locations showed changes from half shrubs[7] to warm season grasses growing in the foreground. Ground cover at one location showed changes from mainly grasses to mainly half shrubs. Junipers became established in the foreground areas of the pictures of 7 of the 14 locations. Juniper was removed at six of the seven locations in the 1940's, 1950's and 1960's; only two of the six locations had not been reinvaded by junipers by 1977. At the seventh location, junipers that became established after 1916 now dominate the site.

Most of the paired pictures show that junipers have increased markedly on the ridges, hills, and mountains in the background of the photographs; however, there is little evidence of increase in size of area covered by shrub live oak, but shrub crown cover within the stands did appear to increase markedly. Changes in brush stand species composition cannot be determined from the photographs.

Double O Division

Figures 1, 2, and 3[8] were taken from the same photopoint on the Turkey Creek flood plain near the Cowden Ranch headquarters at an elevation of 5,140 ft. Grazing use prior to 1916 was probably moderate to heavy since dependable water was available about 2 miles away at the Double O headquarters. Water-spreading dikes, installed between 1945 and 1948, resulted in deposition of about a foot of sediment at the photopoint by 1977.

There is no indication of juniper and little indication of herbaceous vegetation changes in the foreground at this photopoint. The predominant grass, blue grama (*Bouteloua gracilis* (Willd. ex H.B.K.) Lag ex Griffiths), appears more vigorous in the 1977 pictures. The few scattered junipers present on the low ridge in 1916, along with a number of newer trees, were removed in 1955, 1959, and 1960. Utah juniper (*Juniperus osteosperma* (Torr.) Little) are reestablishing on the sites. The brush communities have increased in apparent crown cover but not in area. The juniper stands visible in 1916 on the rolling foothills at left center of figure 2 and on the background hills in figure 3 were cabled in the 1950's.

Figure 4, taken about one-fourth mile south of the first three pictures, shows similar vegetation changes and Turkey Creek eroding into the streambank of Tours loam soil. The drainage bottom, however, is well vegetated with Apache-plume (*Fallugia paradoxa* (D. Don) Endl.), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), and blue grama.

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[7] A half shrub has a herbaceous top growth (stem) that dies back to woody basal growth each year.

[8] All figures appear at the end of the report.

Figure 5 was taken one mile east of the Cowden Ranch headquarters. Although the earlier picture does not show any junipers in the foreground, junipers 4 to 5 ft tall were cabled on this site in 1954. Growth ring counts revealed the trees were 30 to 40 years old when removed, indicating they became established between 1914 and 1924. The understory does not appear to have changed. Blue grama was the principal grass present in 1977; ring muhly (*Muhlenbergia torreyi* (Kunth) Hitchc.), and threeawns (*Aristida* spp.), and sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray) were also common. Scattered clumps of mature junipers visible on the nearby hills in the background in the earlier picture were removed during the 1950's. Junipers are now common there due to new trees and the growth of small trees missed in the tree removal operations.

Bishop Division

Figure 6 was taken 7 miles west of the Cowden Ranch headquarters at an elevation of 5,800 ft on what had been the Bishop Division. This photopoint was on the stock driveway from the Baca Float Ranch to the railhead at Seligman. There appeared to be little change in the foreground vegetation. There were no junipers near the photopoint. Junipers on the hillside in the left of the photograph were bulldozed in 1960. The low hills on the right supported an open, mixed-age juniper stand earlier, but tree growth since then has modified the general aspect to that of a juniper woodland.

Figures 7, 8, and 9 were taken from the same photopoint at an elevation of 5,800 ft south of the Smith and Evans headquarters. The site was moderately grazed before 1916 due to its distance from water. Water development and fencing since then has brought about repeated summer-only use. Plants identifiable in the earlier photograph are Yerba-de-pasmo (*Baccharis pteronioides* DC.), winter fat (*Ceratoides lanata* (Push.) J. T. Howell), buckwheat (*Eriogonum* spp.), indigo bush (*Dalea* spp.), threadleaf groundsel (*Senecio longilobus* Benth.), snakeweed (*Gutierrezia sarothrae* (Pursh) Britt. & Rusby), and saltbush (*Atriplex canescens* (Pursh) Nutt.). The vegetation has changed to a grass community composed principally of blue grama, with some squirreltail (*Sitanion hystrix* (Nutt.) J. G. Sm.), spike muhly (*Muhlenbergia wrightii* Vasey), snakeweed, and groundsel.

The lower valley area in the background of figure 7 shows no evidence of juniper. Snakeweed is the main half shrub present in 1977.

The low hills in the right center of figure 8 had scattered juniper trees present earlier, but by 1977 many more junipers have become established, changing the aspect to that of a juniper woodland. The junipers have increased on the mountains in the far background. Figure 9 shows changes similar to those of figures 7 and 8.

Figure 10 was taken about one and one-half miles from the photopoint for figures 7, 8, and 9 at an elevation of 5,840 ft. There is no indication of junipers in the photograph's foreground. There was a good stand of half shrubs along with western wheatgrass (*Agropyron smithii* Rydb.) and June grass (*Koeleria cristata* (L.) Pers.) in 1916. A windmill and corrals were installed immediately behind the photopoint in the 1940's. The view in the 1977 picture shows the area is heavily used. The half shrubs present in 1977 are snakeweed,

threadleaf groundsel, and rabbitbrush (*Chrysothamnus* spp.). The hillsides have open juniper stand with patches of brush in 1916. The junipers are now more numerous, and, although the brush stands have not increased in area, the crown covers in the stands have increased.

Chino Division

Figure 11 was taken looking down the Prescott-Seligman highway about 5 miles north of Pine Creek at an elevation of 5,500 ft on the Chino Division. No junipers were evident in the foreground in 1916, but 1- to 2-ft tall Utah junipers are now present. Half shrubs were common in 1916. Blue grama, snakeweed, western wheatgrass, and sand dropseed were abundant in 1977. The valley center was free of junipers in the earlier photograph. The gentle alluvial slopes along the sides of the valley had a scattered stand of mature junipers in 1916. The area was cabled in 1955, but a moderately dense stand of junipers is still present and is composed of trees missed by the cabling operation plus newly established trees. The limestone hillsides bordering the valley had a moderately dense juniper stand in 1916 with shrubs forming most of the understory vegetation. The Utah juniper canopy cover increased by 1977. The principal brush species are cliffrose (*Cowania mexicana* D. Don), mountain mahogany (*Cercocarpus betuloides* Nutt.), desert ceanothus (*Ceanothus greggii* Gray), shrub live oak (*Quercus turbinella* Greene), and Apache-plume.

Figure 12 was taken at an elevation of 5,400 ft, one mile southeast of the photopoint for figure 11. The location is immediately east of Big Dam, looking southeast, paralleling the Prescott-Seligman road. There were no junipers evident in the photograph foreground in 1916, but by the mid-1950's trees had become abundant and were removed by cabling in 1958; however, reinvasion has made junipers more numerous now than they were in 1916. The ground cover has changed from half shrubs to grasses. Herbaceous species present on the site in 1977 are blue grama, sand dropseed, fluffgrass (*Tridens pulchellus* (H.B.K.) Hitchc.), threadleaf groundsel, and Russian thistle (*Salsola kali* L.). The low lying ridge in the photograph's left center had a mature juniper stand in 1916. The road and trail shown in the 1916 photograph are no longer visible.

Figures 13, 14, and 15 were taken from the same photopoint along the Prescott-Seligman road. There were no junipers apparent in the foreground at the photopoint in either the 1916 or 1977 photographs, but a number of juniper trunks and stumps are scattered throughout the area, from junipers removed by cabling in 1951 and 1955 and bulldozing in 1963.

Herbaceous ground cover was totally lacking in the foreground of the 1916 photographs. Grazing pressure was probably severe at that time because Cienega Springs, one of the few dependable water sources, is just behind the large hill on the right in figure 14. The dominant vegetation in 1977 was blue grama, snakeweed, sand dropseed, groundsel, vinemesquite (*Panicum obtusum* H.B.K.), barberry, and some Utah junipers.

The stand of juniper trees shown across the middle of figure 14 in 1916 was removed in 1955. On the left slope of figure 15, there were only two large trees in 1916. By 1977, numerous junipers were on the lower slope. The brush stand, however, has remained the same except for an increase in crown cover.

Figure 16 was taken closer to the edge of the transition between the Juniper Mountains and Big Chino Valley. The small trees shown in the foreground of the 1916 photograph increased in both size and number and were removed in 1954. Reestablishment of junipers has been very pronounced in the photograph background where junipers had been cabled in 1955 and bulldozed in 1963. The main plants present in 1977 were tobosa grass (*Hilaria jamesii* (Torr.) Benth.), sideoats grama, sunflower (*Helianthus annuus* L.), snakeweed, blue grama, Apacheplume, and Utah juniper.

A number of small trees were removed from the foreground of figure 17, but there is no indication of junipers on the heavier soils in the bottom land. The ground cover is now mainly bluegrama, squirreltail, western wheatgrass, snakeweed, and groundsel. Junipers have increased markedly on the hills in the background of the photograph. The two trees at the right center midground of the 1916 photograph are still there; the one on the far right is half dead. The other is dead but still standing. The line of trees across the center of the picture follows a drainage. There is now a gulley 3 ft deep where the car was parked in the 1916 photograph. The junipers on the lower slopes of the hill on the right were bulldozed in 1960 and 1963. The brush stands have not changed size very much from 1916 to 1977 but appear more dense.

The foreground of figure 18 was invaded by Utah junipers; the junipers were removed in the 1950's and early 1960's, and the site is again being invaded by junipers. Moderate to severe juniper invasion has occurred in the midforeground. The large tree on the ridge near the left center of the 1916 picture is now a dead standing tree. There was a good stand of tobosa (*Hilaria mutica* (Buckl.) Benth.) in the 1916 photograph. The grass stand was in fair condition in 1977, with blue grama being the most prominant species; however, tobosa and snakeweed are common. Current grazing utilization on this site is high.

The foreground of figure 19 has been invaded by Utah junipers which are now 10 to 12 ft tall. The elevation at this site is 4,840 ft. The juniper stand extends into the distance. The understory has fewer half shrubs and shrubs than it had in 1916. The understory plants in 1977 were blue grama, black grama (*Bouteloua eriopoda* Torr.), pricklypear (*Opuntia* spp.), threeawns, snakeweed, and sideoats grama. The area is currently heavily used by cattle.

In figure 20, the foreground was being invaded by juniper in 1916. These trees were bulldozed in 1963, but junipers are now reestablishing. The hills in the background had moderate to high increases in junipers. The area has been heavily utilized by livestock. In 1977, threeawns, blue grama, winter fat, rabbitbrush, snakeweed, and buckwheat were common. The brush fields on the hillsides do not appear to have changed except in crown cover.

Livestock grazing apparently affected the ground cover markedly. Near dependable water, the vegetation was almost entirely depleted of all but annual weeds by heavy grazing prior to 1916 (figs. 7, 8, and 9). Repeated summer-only grazing during this century may have depleted some of the forage shrubs, such as fourwing saltbush and winterfat, which may have all but disappeared from the area since 1916. The loss of cool-season growing grasses from past yearlong overuse combined with the loss of forage shrubs and their replacement by warm-season growing grasses and junipers have reduced forage not only for livestock but also for wildlife, which use the area all year.

Junipers became established on each of the soil series observed, but did poorly on bottom land sites with Tours and Lynx series soils. Juniper cover increased greatly between 1916 and 1977 on areas with shallow soils underlain by limestone on hillsides and along rocky ridges. Differences in climate, especially rainfall, might modify the relative amounts of juniper establishment on similar soils at other locations. The period between 1916 and 1977 contained several wet cycles that could have aided the trees to become established on the grassland-juniper woodland ecotone; however, past overgrazing also reduced the amount of ground fuels available to carry fires that could kill small junipers.

Junipers, as their crown cover increases, reduce visual openess (fig. 19). Use of such areas by wildlife species, such as antelope, that depend on eyesight for protection against predators, would be affected by this loss of openess. The Utah junipers that are establishing on the grassland areas have an open, multistemmed growth form (fig. 19), unsuited for commercial use as fuelwood or fenceposts. This growth form also indicates the trees are growing under marginal conditions on sites that might be better suited to other species.

CONCLUSIONS

The 20 matched photograph pairs document vegetation changes at 14 grassland-juniper woodland ecotone sites in central Arizona between 1916 and 1977. The availability of land use information between photograph dates helps to explain and elaborate on differences shown. Grazing use markedly affected understory species composition, especially near dependable water prior to 1916 and with repeated summer-only use after 1916. Junipers greatly increased in numbers and size on hillsides and rocky ridges, but did poorly on bottom land sites since 1916. Utah junipers are rapidly reestablishing on areas cleared of Juniper trees in the 1950's and 1960's. The open growth habit of many Utah junipers on grassland-juniper woodland ecotones indicates the trees are growing under marginal conditions on sites that may be better suited to other species. Brush stands of shrub live oak, cliffrose, mountain mahogany, and Apache-plume did not spread although shrub cover in the stands has greatly increased during the past 60 years. Climate, especially rainfall amounts, might change the relative amounts of junipers establishing at these and other locations.

Figure 1.--Near Cowden Ranch headquarters on the Turkey Creek flood plain, SE. ¼ Sec. 5, T. 20 N., R. 6 W., looking southwest. Top 1916, bottom 1977. Foreground looks unchanged. Background shows juniper cover increase and evidence of juniper clearing at the bases of the hills before 1977.

Figure 2.--Same location as figure 1, looking southeast. Top 1916, bottom 1977. Similar in appearance to figure 1.

Figure 3.--Same location as figure 1, looking east southeast. Top 1916, bottom 1977. Similar in appearance to figure 1.

Figure 4.--About one-quarter mile south of the photopoint for figure 1, E. ½ Sec. 8, T. 20 N., R. 6 W., looking southeast up Turkey Creek towards the Juniper Mountains. Top 1916, bottom 1977. Gulley seems to be healing in 1977. Juniper has increased cover on the hills in the background, but the foreground looks similar in both photos.

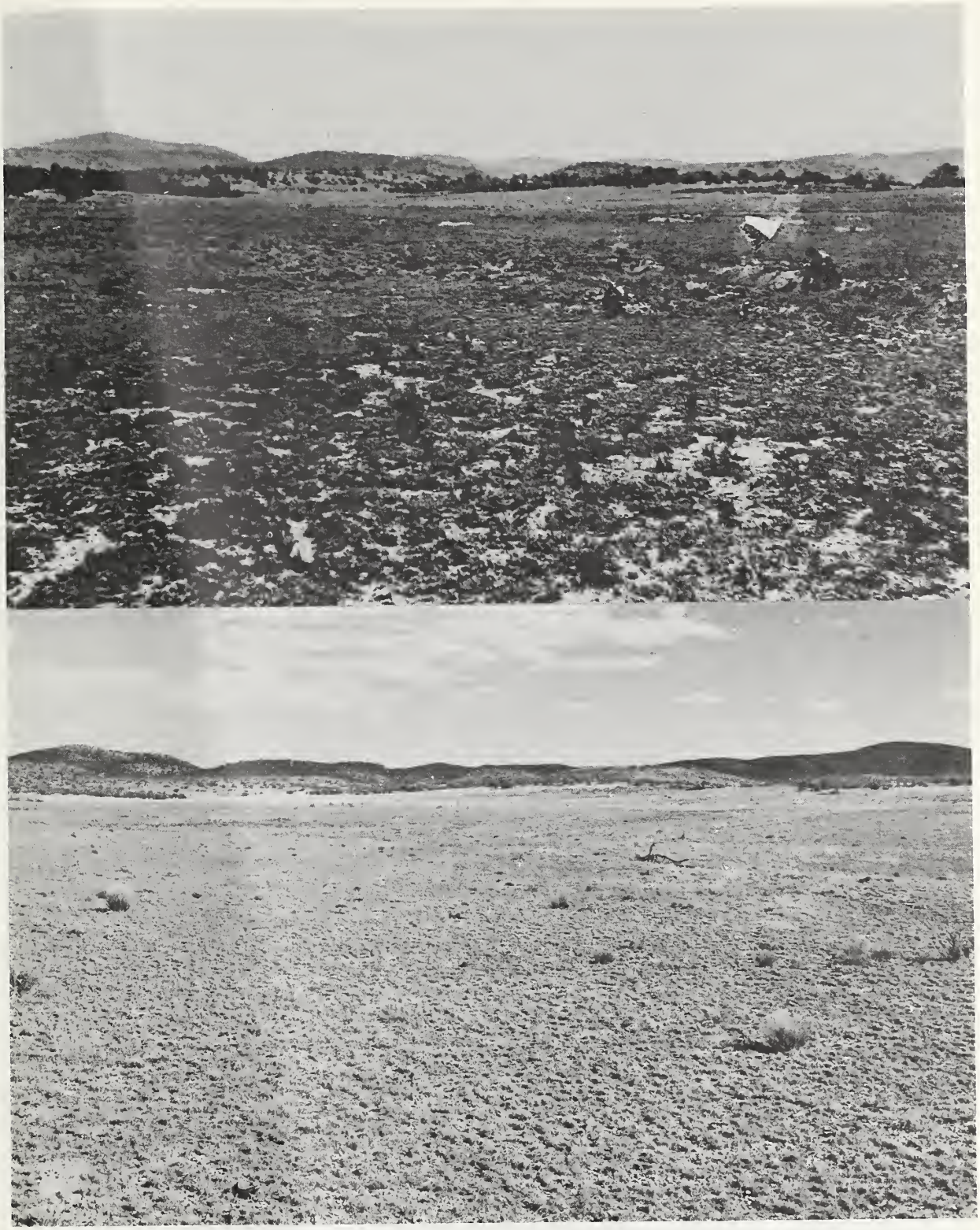

Figure 5.--One mile east of Cowden Ranch headquarters, center Sec. 4, T. 20 N., R. 6 W., looking east. Top 1916, bottom 1977. Looks unchanged. Juniper had established here, but were cleared when they were 4 to 5 ft tall.

Figure 6.--Seven miles west of Cowden Ranch headquarters, S. ½ Sec. 16, T. 20 N., R. 7 W., looking east northeast. Top 1916, bottom 1977. Very little change. The hillside was cleared in 1955. This site was on the cattle driveway.

Figure 7.--About 2 miles south of Smith and Evans headquarters, 100 yards northeast of the section corner for Sec. 5, 6, 7, and 8, T. 19 N., R. 7 W., looking northeast. Top 1916, bottom 1977. Foreground changed from half shrubs to short grasses. Junipers along bottom of hills cleared before 1977.

Figure 8.--Same location as figure 7, looking east. Top 1916, bottom 1977. Foreground changed from half shrubs to short grasses. Junipers becoming more numerous on hills in background.

Figure 9.--Same location as figure 7, looking southeast. Top 1916, bottom 1977. Changes similar to those shown in figure 7. Note powerlines crossing the area in 1977.

Figure 10.--About 1⅓ miles east southeast of figure 7, NW. ¼ Sec. 9, T. 19 N., R. 7 W., looking southeast. Top 1916, bottom 1977. Foregrounds similar in each picture. Junipers more numerous on hills in 1977. Little change in size of brush stand areas, but the stands look denser. Photopoint adjacent to a corral.

Figure 11.--Along Seligman-Prescott road, 5 miles north of Pine Creek, E. ½ Sec. 36, T. 20 N., R. 6 W., looking south. Top 1916, bottom 1977. Foreground vegetation changed to short grasses. Juniper on hills more numerous and larger.

Figure 12.--Immediately east of Big Dam, one mile southeast of figure 10, W. ½ Sec. 6, T. 19 N., R. 6 W., looking southeast. Top 1916, bottom 1977. Changed from half shrubs to short grasses in foreground. Numerous small junipers along flat and on hills.

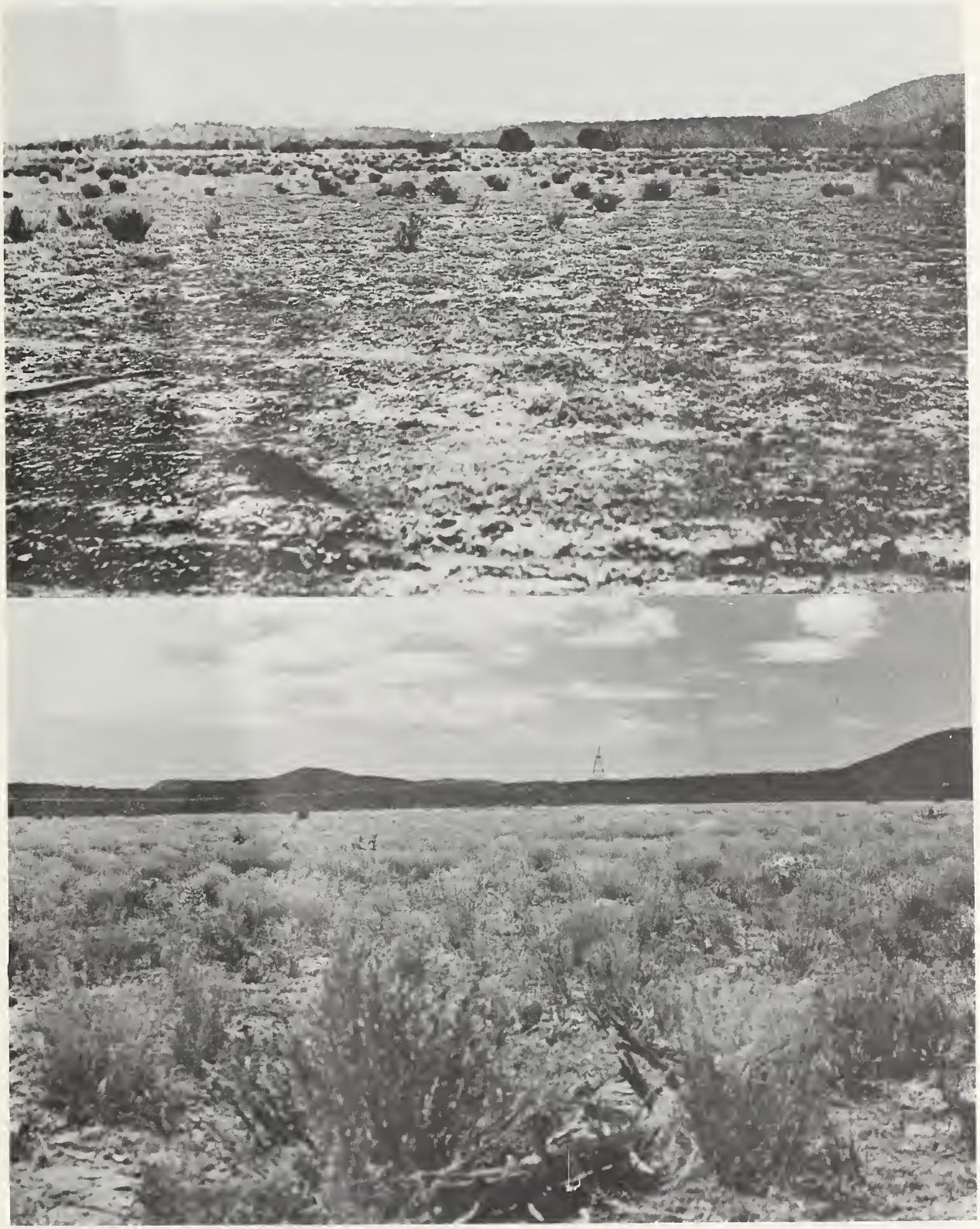

Figure 13.--About 200 yards east of the Seligman-Prescott road, NW. ¼ Sec. 17, T. 19 N., R. 5 W., looking southwest. Top 1916, bottom 1977. More half shrubs in the foreground. Note powerlines crossing area in 1977.

Figure 14.--Same location as that shown in figure 13, looking southeast. Top 1916, bottom 1977. Half shrubs and blue grama forming ground cover in 1977.

Figure 15.--Same location as that shown in figure 13, looking east. Top 1916, bottom 1977. Half shrubs and grasses look denser in 1977. Junipers have increased on hillside to the left.

Figure 16.--Along the Pine Creek road, N. ½ SE. ¼ Sec. 22, T. 19 N., R. 5 W., looking west. Top 1916, bottom 1977. Area was being invaded by juniper in 1916. The trees were cleared, but the juniper is reinvading.

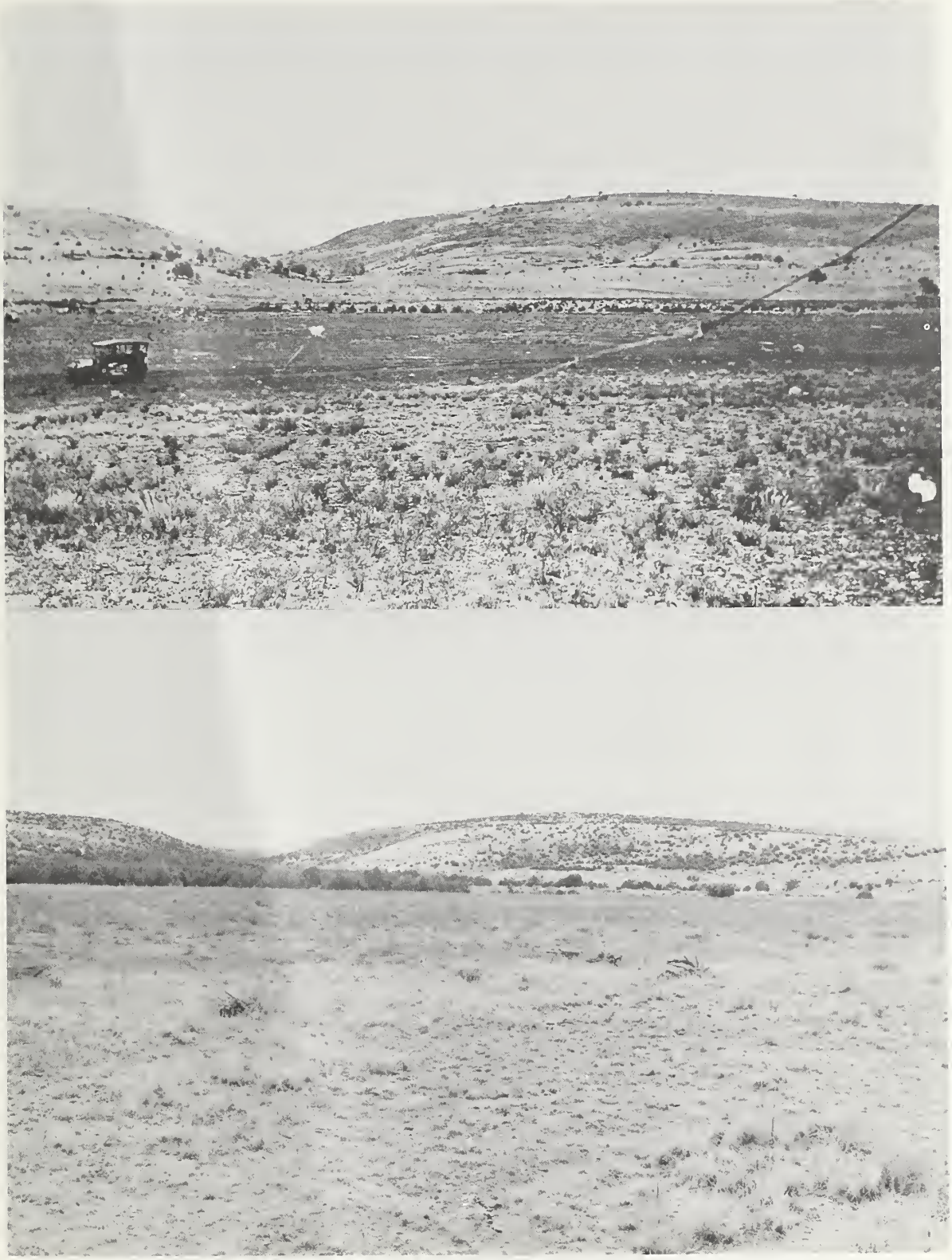

Figure 17.--About three-quarters of a mile south of the Pine Creek road, SE. ¼ Sec. 22, T. 19 N., R. 5 W., looking southwest. Top 1916, bottom 1977. Better grass cover in foreground. Marked increase in junipers in background.

Figure 18.--Just off Pine Creek road, E. ½ Sec. 23, T. 19 N., R. 5 W., looking northeast. Top 1916, bottom 1977. Junipers had been cleared but are again reestablishing.

Figure 19.--About one-half mile north of the Pine Creek road, NE. ¼ Sec. 24, T. 19 N., R. 5 W., looking northwest. Top 1916, bottom 1977. Junipers have become established on the site, and are beginning to dominate it.

Figure 20.--Just off Seligman-Prescott road, NW. ¼ SE ¼ Sec. 4, T. 18 N., R. 5 W., looking northeast. Top 1916, bottom 1977. Junipers had been cleared prior to 1977 and are reestablishing. Junipers have increased on the hills in the background.

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